Chapter 7 Introduction to Best Management Practices

This chapter provides an overview of structural Best Management Practices for managing and treating stormwater runoff. It includes a brief description of post-construction pretreatment and treatment practices for long-term management of stormwater, as well as an introduction to temporary (construction phase) practices. This chapter also discusses the screening and selection of structural best management practices and their operation and maintenance needs.

Structural BMPs should be considered only after non-structural site design techniques, discussed in Chapter 6, have been implemented to reduce the volume of stormwater runoff. While the goal is to minimize the generation of runoff requiring treatment, it is anticipated that many projects will still require structural BMPs to treat the stormwater from the remaining connected impervious surfaces. Structural BMPs are designed to remove pollutants from stormwater runoff as well as provide for groundwater recharge, peak runoff attenuation, and stream channel protection.

Note that Volume 2 of the New Hampshire Stormwater Manual addresses the selection and design of BMPs in greater detail, along with additional information on operation and maintenance. Volume 3 of the Manual provides additional detailed discussion of construction phase practices.

7-1. Pre-Treatment Practices

Pre-treatment practices are used to treat runoff prior to a permanent best management practice to settle out coarse sediments, slow runoff velocities, and in some cases, provide additional treatment (such as removal of floating debris and oil). This increases overall pollutant removal and reduces the maintenance requirements on permanent treatment practices.

Pretreatment Practices include the following measures:

Sediment Forebays

A sediment forebay is an impoundment, basin, or other storage structure designed to dissipate the energy of incoming runoff and allow for initial settling of coarse sediments. Forebays are used for pretreatment of runoff prior to discharge into the primary water quality treatment BMP. In some cases, forebays may be constructed as separate structures but often, they are integrated into the design of larger stormwater management structures.

Vegetated Filter Strips

Filter strips (grassed filter strips, vegetated filter strips, grass filters) are vegetated surfaces designed to treat stormwater sheet flow. Filter strips are designed to slow stormwater velocity, filter out sediment and associated pollutants, and provide minimal infiltration of runoff. Filter strips are most appropriate for receiving sheet flow runoff before it enters another treatment practice or leaves a site. They function best at removing sediment. They also provide wildlife habitat and travel corridors.

A level spreader may be necessary to convert runoff to sheet flow as it enters the filter strip. Vegetation may consist of meadow, forest, or a combination. Vegetated Filter Strips may have substantially shorter lengths of flow path than "Vegetated Buffers," and would not be anticipated to provide the level of treatment afforded by buffers sized in accordance with the Alteration of Terrain regulations (Env-Wq 1500). Therefore, Filter Strips are not considered "Treatment Practices" but may be used as pretreatment practices.

Pre-treatment Swales

Pre-treatment swales are shallow, linear, vegetated, earthen channels designed to convey flows, while capturing a limited amount of sediment and associated pollutants. A pre-treatment swale differs from a Treatment Swale in that the pre-treatment swale is not designed for a specified hydraulic residence time, but only for a minimum length. Therefore, pre-treatment swales do not necessarily provide sufficient time for the removal of pollutants other than those associated with larger sediment particles, and may only be used for pretreatment.

Flow Through Devices

Flow-through devices can provide pre-treatment of stormwater runoff before entering a treatment practice. These devices include:

Water Quality Inlet
A water quality inlet is an underground storage structure with multiple chambers, designed to capture coarse sediments, floating debris, and some hydrocarbons from stormwater runoff. Such inlet devices are typically used for pretreatment of runoff prior to discharge to another treatment practice.

The devices use baffles with weirs or orifices to control flow and help capture sediment, and inverted baffles or hooded outlets to help capture floating materials. Depending on the design of the unit and the magnitude of peak flow events, the captured sediments may be subject to re-suspension and flushing from the device. Floating hydrocarbons captured in the unit can be removed for disposal during maintenance operations by skimming or by use of sorbent materials. To limit potential for re-suspension of captured materials, the device is usually designed as an "off-line" unit sized for the Water Quality Flow. Larger storm events would then bypass the unit.

Proprietary Flow Through Devices

Proprietary flow through devices may be used for pretreatment of stormwater. Several manufacturers offer a number of proprietary flow-through stormwater treatment devices. These devices are variously referred to as "oil/particle separators," "oil/grit separators," or "hydrodynamic separators." Some of these devices use multiple chambers arranged horizontally or vertically to help trap and retain sediments and floating substances. Some use internal components to promote a swirling flow path to help enhance removal and retention of sediment.

These flow-through devices are normally sited close to the source of runoff, often receiving stormwater from relatively small areas that are mostly, if not entirely, impervious surface. They may only be used as pretreatment of stormwater prior to discharge to other treatment BMPs added.

Deep Sump Catch Basins

A deep sump catch basin consists of a manhole-type structure with an inlet grate, an outlet pipe connected to the piped drainage system, and a sump with a depth several times the diameter of the outlet pipe. The inlet grate is located at the surface, and is sometimes combined with a vertical inlet integrated with a street or parking area curb. The sump's purpose is to capture coarse sediments and debris from the runoff intercepted by the structure. The outlet pipe can be fitted with a "hood" consisting of a cast metal or formed plastic fitting, designed to prevent floating materials from exiting the structure.

Deep sump catch basins used as pretreatment are most effective when they only receive flow from the inlet grate (i.e. no piped inflow from adjacent catch basins) since flow-through basins are more susceptible to sediment re-suspension. The outlet hood provides benefits for trapping floating trash, as well as for short-term spill containment.

7-2. Treatment Best Management Practices

NHDES recognizes the following categories of primary BMPs to treat stormwater runoff. These BMPs provide water quality treatment and are permanent practices for post-construction stormwater management.

Stormwater Ponds

Stormwater ponds are impoundments designed to collect, detain and release stormwater runoff at a controlled rate. They provide treatment through the use of a permanent pool, which helps settle solids and associated pollutants. Extended detention features can be incorporated into stormwater ponds by combining permanent micropools or other permanent pool storage with an extended drawdown time of the water quality volume.

In addition to water quality benefits, by providing additional storage capacity and a multi-stage outlet structure, stormwater ponds can also be designed to provide flood control.

The following are examples of Stormwater Ponds:

Micropool Extended Detention Pond

An extended detention pond with a micropool temporarily stores and releases the Water Quality Volume over an extended drawdown time. The micropool is typically provided near the outlet, to enhance pollutant removal and to help prevent resuspension of captured sediments. Except for the micropool, the basin is designed to be dry between storms, once the WQV has been discharged. The basin provides pollutant removal by settling of sediments and associated pollutants.

Wet Pond

Wet ponds are designed to maintain a permanent pool of water throughout the year. The pool, located below the outlet invert, allows for pollutant removal through settling and biological uptake or decomposition.

Wet ponds, if properly sized and maintained, can achieve high rates of removal for a number of urban pollutants, including sediment and its associated pollutants: trace metals, hydrocarbons, BOD, nutrients and pesticides. They also provide some treatment of dissolved nutrients through biological processes within the pond.

Wet Extended Detention Pond

Wet extended detention ponds combine the features of wet ponds and extended detention ponds. The combined permanent pool and extended detention volume can be used to treat the Water Quality Volume and meet Channel Protection requirements .

Multiple Pond System

The multiple pond system is similar to the wet pond, except that the total treatment volume is distributed over two or more pond "cells," rather than a single pond. This type of design can be useful for adapting the component ponds to fit a particular site layout, provide for a more aesthetic design, or address changes in elevation on a sloping site.

Pocket Pond

The pocket pond is a wet pond or wet extended detention pond designed to serve a small contributing area. While similar to other wet ponds and wet extended detention ponds in design, the water budget for this pond will likely depend on the presence of groundwater, because the smaller contributing watershed would not sustain a permanent pool. Note that NHDES considers a "wet swale" type of water quality swale to be a "pocket pond."

Stormwater Wetlands

Stormwater wetlands are similar to stormwater ponds in that the design includes a permanent pool of water. However, the retained pool is designed with varying depths to support a wetland plant community. In addition to the settling processes that occur in the permanent pool, stormwater wetlands provide pollutant removal/uptake by vegetation and by other biological activity supported within the wetland environment. In some stormwater wetlands, such as "gravel wetlands," the systems provide filtration, as well.

Stormwater wetlands are constructed depressions or impoundments designed to function similar to natural wetlands. However, unlike natural wetlands, stormwater wetlands are designed specifically to treat stormwater. It is important to stress the distinction between using constructed wetlands to treat stormwater versus directing untreated runoff to a natural wetland. The direct discharge of stormwater runoff to natural wetlands is typically not allowed in NH. It alters the critical wetland hydrology and increases the potential to degrade wetland habitat. It can also cause stress to plants and animals and contribute to die-off of these species. Natural wetlands should be protected and should not be used to treat stormwater runoff.

The following are examples of Stormwater Wetlands:

Shallow Wetlands

Shallow wetlands for stormwater treatment consist of pools ranging from 6 to 18 inches in depth under normal conditions, with some areas of deepwater pools. They may be configured with a variety of low marsh and high marsh "cells" with sinuous channels to distribute flows to maximize retention time and contact area. Shallow wetland systems are designed with wetland vegetation suitable for these varying depths. The entire Water Quality Volume is provided within the deepwater, low marsh, and high marsh zones.

Extended Detention Wetlands

Extended detention stormwater wetlands typically require less space than shallow wetlands systems, because part of the Water Quality Volume is stored above the level of the permanent pool. Deepwater areas tend to be less extensive and semi-wet areas more extensive than those provided for shallow wetlands. Wetland plants that tolerate both intermittent flooding and dry periods must be selected for the area above the permanent marsh.

Pond/Wetland System

The wetlands/pond system for stormwater treatment consists of a series of cells using at least one wet pond in combination with shallow marsh wetlands. The first cell typically comprises the wet pond, which provides initial treatment primarily by settling of particulates. The wet pond can also reduce the velocity of runoff entering the system. The shallow marsh provides subsequent additional treatment of the runoff, particularly for soluble pollutants through vegetative uptake and the biological activity associated with the wetland vegetation community. With the deeper pool of the wet pond, these systems can typically require less space than the shallow marsh system.

Gravel Wetlands
The gravel wetland system consists of one or more flow-through constructed wetland cells, preceded by a forebay. The cells are filled with a gravel media, supporting an organic substrate that is planted with wetland vegetation. During low-flow storm events, the system is designed to promote subsurface horizontal flow through the gravel media, allowing contact with the root zone of the wetland vegetation. The gravel and planting media support a community of soil microorganisms. Water quality treatment occurs through microbial, chemical, and physical processes within this media. Treatment may also be enhanced by vegetative uptake.

The system can be designed to integrate some stormwater storage, and also to provide infiltration. With these features, the practice would not only remove pollutants, but also contribute to the attenuation of peak rates through temporary storage and reduction in runoff volume through infiltration and evapotranspiration.

Infiltration Practices

Infiltration practices are designed to capture and temporarily store the water quality volume of stormwater while it infiltrates into the soil. Infiltration practices help to recharge groundwater, but must be designed and maintained to avoid clogging and system failure. Pollutants are removed through adsorption of pollutants onto soil particles, and biological and chemical conversion in the soil.

Infiltration practices differ from filtering practices in that stormwater is infiltrated through native soil and allowed to recharge groundwater, while filtration practices typically employ non-native soil materials or other media, and may use underdrains to convey the filtered water to discharge.

Examples of Infiltration Practice are provided below. Note that "permeable pavements," discussed under "Filtering Practices," may also be designed to provide for infiltration.

Infiltration Trench (Including Drip Edge)
An infiltration trench is a stone-filled excavation used to temporarily store runoff and allow it to infiltrate into surrounding, natural soil. Typically, runoff enters the trench as overland flow after pretreatment through a filter strip or vegetated buffer. An infiltration trench is suitable for treating runoff from small drainage areas (less than 10 acres). Installations around the perimeter of parking lots, between residential lots, and along roads are most common. Infiltration trenches can also be incorporated along the center of a vegetated swale to increase its infiltration ability.

An infiltration drip edge is constructed similar to an infiltration trench, except that a drip edge intercepts only roof runoff, and does not require pretreatment.

In-Ground (Surface) Infiltration Basin

In-ground infiltration basins are impoundments designed to temporarily store runoff, allowing all or a portion of the water to infiltrate into the ground. An infiltration basin is designed to completely drain between storm events. An infiltration basin is specifically designed to retain and infiltrate the entire Water Quality Volume. Some infiltration basins may infiltrate additional volumes during larger storm events, but many will be designed to release stormwater exceeding the water quality volume from the larger storms. In a properly sited and designed infiltration basin, water quality treatment is provided by runoff pollutants binding to soil particles beneath the basin as water percolates into the subsurface. Biological and chemical processes occurring in the soil also contribute to the breakdown of pollutants. Infiltrated water is used by plants to support growth or it is recharged to the underlying groundwater.

Underground (Subsurface) Infiltration Basin

Infiltration basins are structures designed to temporarily store runoff, allowing all or a portion of the water to infiltrate into the ground. The structure is designed to completely drain between storm events. An underground infiltration basin is specifically designed to retain and infiltrate the entire Water Quality Volume. Some infiltration basins may infiltrate additional volumes during larger storm events, but many will be designed to release stormwater exceeding the water quality volume from the larger storms. In a properly sited and designed infiltration basin, water quality treatment is provided by runoff pollutants binding to soil particles beneath the basin as water percolates into the subsurface. Biological and chemical processes occurring in the soil also contribute to the breakdown of pollutants. Infiltrated water is recharged to the underlying groundwater.

Subsurface infiltration basins may comprise a subsurface manifold system with associated crushed stone storage bed, or specially-designed chambers (with or without perforations) bedded in or above crushed stone.

Dry Well & Leaching Basin

Dry wells are essentially small subsurface leaching basins. The dry well consists of a small pit filled with stone, or a small structure surrounded by stone, used to temporarily store and infiltrate runoff from a very limited contributing area. Runoff enters the structure through an inflow pipe, inlet grate, or through surface infiltration. The runoff is stored in the structure and/or void spaces in the stone fill. Properly sited and designed dry wells provide treatment of runoff as pollutants become bound to the soils under and adjacent to the well, as the water percolates into the ground. The infiltrated stormwater contributes to recharge of the groundwater table.

Dry wells are well-suited to receive roof runoff via building gutter and downspout systems. With the small size and manageable cost of these BMPs, they are particularly suited for use in subdivisions and for single-family homes. When used for roof drainage, pretreatment of runoff is not typically required.

Leaching basins are dry wells used in well drained soils for the discharge of roadway or parking area runoff. In this case, pretreatment is required prior to discharge to the leaching basin. A typical arrangement is to use a deep sump, hooded catch basin in combination with a leaching basin.

Filtering Practices

Filtering practices treat stormwater runoff by capturing and passing the water quality volume through a bed of sand, other soil material, or other acceptable treatment media to remove pollutants from the water. Sediments and other pollutants are removed by physical straining and adsorption. Filters can be constructed using common materials, or proprietary systems using various filter media can be employed. Filtration BMPs have shown to be very effective at removing a wide range of pollutants from stormwater runoff, particularly when organic soil filter media have been used.

Filtering practices differ from infiltration practices in that the stormwater filters through an engineered filter media, rather than native soil. However, filtering practices can be constructed in combination with infiltration practices, where the filtered water is discharged into the ground beneath the BMP.

Alternatively, filters can be designed with an underdrain to collect the treated water and convey it to discharge. Underdrained filters can be lined to isolate the filters from the adjacent soil material or underlying groundwater.

The following are examples of filtering practices:

Surface Sand Filter
The surface sand filter is typically designed as an off-line device, so that storms exceeding the water quality volume are diverted from the BMP. Thus, the system usually includes a flow splitter, used to divert the first flush of runoff into a pretreatment device, such as a sedimentation chamber (wet or dry) where coarse sediments settle out of the water. Pretreated runoff then enters the sand filter, saturating the filter bed and filling temporary storage volume provided above the bed. As the water filters down through the sand bed, pollutants are strained from the water or adsorbed to the filter media. The top surface of the sand filter is exposed to the elements, but is kept free of vegetation.

If the filter is designed for infiltration, the treated water is allowed to percolate into the underlying native soil. Alternatively, the filter can be designed with a perforated underdrain system to collect treated water at the bottom of the sand filter and direct it to a suitable outlet. If necessary, the underdrained sand filter can be designed with a liner to isolate it from adjacent soil material and prevent discharge of treated water to the groundwater table.

Underground Sand Filter

The underground sand filter operates in a similar fashion to the surface sand filter, except that the system is enclosed in a below-grade structure. The structure may consist of a multi-chambered vault that accommodates pretreatment, as well as the filtration component of the system. The structure is made accessible through manholes or grate openings. Typical subsurface filter systems are fully enclosed in structures. However, some systems may be designed with an open bottom in contact with native soils, allowing for infiltration to occur.

Bioretention System

A bioretention system (sometimes referred to as a "rain garden") is a type of filtration BMP designed to collect and filter moderate amounts of stormwater runoff using conditioned planting soil beds, gravel beds and vegetation within shallow depressions. The bioretention system may be designed with an underdrain, to collect treated water and convey it to discharge, or it may be designed to infiltrate the treated water directly to the subsoil. Bioretention cells are capable of reducing sediment, nutrients, oil and grease, and trace metals. Bioretention systems should be sited in close proximity to the origin of the stormwater runoff to be treated.

The major difference between bioretention systems and other filtration systems is the use of vegetation. A typical surface sand filter is designed to be maintained with no vegetation, whereas a bioretention cell is planted with a variety of shrubs and perennials whose roots assist with pollutant uptake. The use of vegetation allows these systems to blend in with other landscaping features.

Tree Box Filter

The Tree Box Filter consists of an open bottom or closed bottom concrete box or barrel filled with a porous soil media. An underdrain system, consisting of a perforated pipe bedded in crushed gravel, is provided beneath the soil media. A tree is planted in the soil media. Stormwater is directed from surrounding impervious surfaces through the top of the soil media.

If the device has an open bottom, the stormwater percolates through the media into the underlying ground. If the filtered stormwater exceeds the infiltration capacity of the underlying natural soil, the excess will be intercepted by the underdrain, where it may be directed to a storm drain, other device, or surface water discharge.

Where a closed bottom box filter is used, such as where necessary to protect groundwater resources, the filter is isolated from the underlying soil. In this case, all of the stormwater that passes through the soil media filter will be intercepted by the underdrain and conveyed to a suitable outlet.

Permeable Pavement

Permeable pavement consists of a porous surface, base, and sub-base materials which allow penetration of runoff through the surface into underlying soils. The surface materials for permeable pavement can consist of paving blocks or grids, pervious asphalt, or pervious concrete. These materials are installed on a base which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground.

Although traffic loading capacities vary, permeable pavement alternatives are generally appropriate for low traffic areas (e.g. sidewalks, parking lots, overflow parking, residential roads). Careful maintenance is essential for long term use and effectiveness.

Frequently, permeable pavements filter only the runoff generated on the pavement surface itself. However, runoff from other areas can be directed to permeable pavement if properly designed. Runoff generated from adjacent areas of the site may require pretreatment prior to discharge to the pavement surface, to prevent clogging of the pavement structure and (where the pavement is used to infiltrate as well as filter the runoff) the underlying soils.

Treatment Swales

Treatment swales are designed to promote sedimentation by providing a minimum hydraulic residence time within the channel under design flow conditions (Water Quality Flow). This BMP may also provide some infiltration, vegetative filtration, and vegetative uptake. Conventional grass channels and ditches are primarily designed for conveyance. Treatment swales, in contrast, are designed for hydraulic residence time and shallow depths under water quality flow conditions. As a result, treatment swales provide higher pollutant removal efficiencies. Pollutants are removed through sedimentation, adsorption, biological uptake, and microbial breakdown.

Treatment swales also differ from practices such as underdrained swales (for example, “dry swales” and “bioretention swales”), which are essentially filtration practices, and “wet swales,” which are similar in function to pocket ponds.

Vegetated Buffers

Vegetated buffers are areas of natural or established vegetation allowed to grow with minimal to no maintenance. Buffers reduce the velocity of runoff as it flows through the vegetation. Buffers also provide a permeable area where runoff can infiltrate the soil. They promote groundwater recharge, filter out sediments, and create shade to maintain water temperatures. They can also provide wildlife habitat and connect habitat corridors.

Buffers are often provided along the shoreline of waterbodies and wetlands, and may be controlled at the municipal level through buffer requirements and development setbacks. Although municipal buffer requirements are recommended, it may not be appropriate to arbitrarily set a standard buffer width. Instead, a municipality can establish buffer guidelines to determine buffer widths that are dependent on site conditions and goals for individual sites.

Vegetated buffers include, but are not limited to:

Residential or Small Pervious Area Buffer
This type of vegetated buffer is for individual residential lots or for developments with limited areas of impervious surface, where runoff enters the buffer as sheet flow without the aid of a level spreader. This type of buffer can be sited adjacent to single family or duplex residential structures, or impervious surfaces where flow length over the surfaces is limited. This design is not appropriate for treating large impervious areas where there is the likelihood for runoff flows to concentrate and create channels through the buffer instead of discharging as dispersed sheet flow.

Developed Area Buffer
Developed Area Buffers serve areas that exceed the thresholds for "residential or small pervious area buffers." They may also be used for small areas where the runoff is discharged as concentrated flow, rather than sheet flow. Developed area buffers require the use of stone-berm level spreaders to discharge runoff into the buffers as sheet flow. Runoff is directed to the channel upstream of the stone berm, which is located along the contour of the slope at the upper margin of the buffer area. This stone berm spreads the runoff so that it uniformly seeps through the berm and evenly distributes across the top of the buffer as sheet flow.

Roadway Buffers
A buffer adjacent to the down-hill side of a road should be sited directly adjacent to the roadway. In addition, the road must be parallel to the contour of the slope. Runoff must sheet immediately into the buffer, and must not include runoff from areas other than the adjacent road surface and shoulder. The buffer may consist of man-made buffer, natural buffer, or a combination.

Ditch Turn-out Buffer
A ditch turn-out buffer diverts runoff collected in a roadside ditch into a buffer. A combination of check dams and bermed level lip spreaders convert the concentrated ditch flows into sheet flow. The sheet flow distributes across the top of the buffer.

7-3. Construction-Phase Management Practices

Temporary management practices are intended to protect disturbed soils and stabilize areas during construction until vegetation or other permanent management measures are installed. Temporary measures are expected on all construction sites and are not factored into pollutant load reduction calculations. Temporary measures typically include both erosion control practices and sediment control practices.

Erosion Control Practices

Erosion controls are employed to prevent the displacement of soils by wind, rainfall, and runoff. These measures depend on limiting areas of disturbance of soils, limiting times of duration of soil disturbance, careful land grading practices, and the implementation of measures to maintain undisturbed surfaces and stabilize disturbed surfaces. Typical erosion control and stabilization practices include:

Construction Phasing

Land alteration is an essential component of site development and building construction, and is often required for redevelopment as well. Land grading consists of shaping the existing land surface in accordance with a plan determined by engineering survey and layout. This activity must be performed in a manner to minimize exposure of slopes to runoff and potential erosion, provide for stable permanent slopes, and facilitate the establishment of vegetation.

During construction, land grading practices intended to minimize impacts of surface runoff and erosion include:

- Planning earth disturbance and grading activities so as to minimize the area of soil exposed at one time, as well as the length of time between initial soil exposure and final grading. On large projects this is accomplished by phasing the operation.
- Protecting existing vegetation and natural forest cover.
- Preserving and maintaining buffer strips of undisturbed vegetation.
- Diverting clean water away from the immediate construction area.
- Dispersing clean stormwater to undisturbed, vegetated, flat or moderate-sloped, surfaces wherever possible, rather than concentrating it into channels.
- Upgrading and refining the implementation of fall and winter erosion control measures to protect the site from spring runoff and snowmelt.

Dust Control

Dust control consists of applying various measures to prevent blowing and movement of dust from exposed soil surfaces. This practice is applicable to areas subject to dust blowing and soil movement where on-site and off-site damage is likely to occur if preventive measures are not taken. Typical dust control measures include traffic control, construction phasing, and maintenance of existing vegetation to limit exposure of soils and prevent conditions that result in dry soils and dust; application of water, calcium chloride, and temporary stabilization practices to control mobilization of dust by equipment operation or wind; and pavement sweeping to prevent accumulation of dust-producing sediment.

Surface Roughening

Surface roughening is a technique for creating furrows in a bare soil surface, by tracking the slope with construction equipment. The purpose of surface roughening is to aid the establishment of vegetative cover from seed, to reduce runoff velocity and increase infiltration, and to reduce erosion and provide for sediment trapping. This practice applies to all construction slopes to facilitate long-term stabilization with vegetation, and particularly slopes steeper than 3:1.

Soil Stockpile Practices

Soil stockpile practices include measures to locate, manage, and protect stockpiled earth materials to reduce or eliminate wind and water erosion, and prevent resulting air and water pollution from displaced sediment. Stockpile practices apply to topsoil, excavated materials, borrow materials imported to the site, and construction aggregates and paving materials that are stockpiled on the site prior to use in the construction work.

Temporary & Permanent Mulching

Temporary mulching consists of the application of plant residues or other suitable materials to the soil surface. Mulching prevents erosion by protecting the exposed soil surface from direct impact by rainfall. It also aids in the growth of vegetation by conserving available moisture, controlling weeds, and providing protection against extreme heat and cold. Mulches can also protect the infiltration rate of the soil, prevent soil compaction, and provide a suitable microclimate for seed germination. This is the quickest and most cost effective method of preventing erosion on disturbed soils and its value should not be underestimated.

Permanent mulch consists of the application of long-term surface cover such as bark, wood chips, or erosion control mix. Permanent mulch can be used as a permanent ground cover, as an overwinter stabilization mulch, or left to naturalize. It is not designed to support grass vegetation, but legumes or woody vegetation may be established for additional stability.

Temporary and permanent mulches may consist of hay or straw, wood chips or bark, or erosion control mix (a mixture of fibrous organic materials such as from shredded bark, stump grindings, composted bark, or equivalent manufactured products). Please note that hay mulch can contain a variety of seeds some of which may be invasive plants such as reed canary grass and purple loosestrife. It is suggested that hay mulches not be used near important resources such as wetland streams and lakes to prevent the spread of invasive plants .

Temporary Vegetation

Temporary vegetation consists of the establishment of a grass and legume cover on exposed soils for periods of up to 12 months. The purpose is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a year or less and to reduce problems associated with mud and dust production from exposed soil surfaces during construction. Temporary seeding is also essential to preserve the integrity of earthen structures used to control sediment, such as diversions and the embankments of sediment basins.

Runoff and sheet erosion caused by splash erosion (rain drop impact on bare soil) is the source of most fine particles in sediment. To reduce the sediment load in runoff, the soil surface itself should be protected. The most effective and economical means of controlling sheet and rill erosion is to establish a vegetative cover. Annual plants that sprout rapidly and survive for only one growing season are suitable temporary vegetative cover.

Permanent Vegetation

Permanent vegetative cover should be established on disturbed areas where permanent, long lived vegetative cover is needed to stabilize the soil, to reduce damages from sediment and runoff, and to enhance the environment. The most effective and economical means of controlling sheet and rill erosion is to establish a permanent vegetative cover.

Temporary Erosion Control Blanket

Erosion control blankets or mats consist of protective manufactured mulch blankets, installed on prepared soil surfaces to provide erosion protection and surface stability on steep slopes, vegetated channels, or shorelines during vegetation establishment. Erosion control blankets temporarily stabilize and protect disturbed soil from raindrop impact and surface erosion. Like other types of mulch, the blankets help increase infiltration, decrease compaction and soil crusting, and conserve soil moisture. Erosion control blankets increase the germination rates for grasses and legumes and promote vegetation establishment. Erosion control blankets also protect seeds from predators and reduce desiccation and evaporation by insulating the soil and seed environment.

Erosion control blankets generally consist of machine-made mats made of organic, biodegradable mulch such as straw, curled wood fiber (excelsior), coconut fiber or a combination thereof, evenly distributed on or between manufactured netting. Netting is typically composed of photodegradable polypropylene or biodegradable natural fiber.

Erosion control blankets can be applied to steep slopes, vegetated waterways, and other areas sensitive to erosion, to supplement vegetation during initial establishment and help provide for safe conveyance of runoff over the protected surface.

Diversion

A diversion is a temporary channel constructed across the slope to intercept runoff and direct it to a stable outlet or to sediment trapping facilities. The channel may be formed by excavation, placement of a berm (or dike), are a combination of these measures. This temporary measure is used immediately above a new cut or soil fill slope or around the perimeter of a disturbed area. Diversion practices themselves should be stabilized.

Diversions can be used to direct storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet. In this case the diversion is placed upslope of the construction area. They can also be used to divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a sediment trap or sediment basin. In this case, the diversion is placed below the disturbed area, to assure that sediment-laden runoff will not leave the site without treatment.

Diversions are intended to facilitate management of the site during construction, and should not be substituted for terracing, vegetated waterways, permanent land grading practices, or other permanent measures for providing long-term erosion control.

Slope Drain

A slope drain comprises a pipe, flexible tubing, or other conduit extending from the top to the bottom of a cut or fill slope. During construction, cut and fill slopes are exposed to erosion between the time they are graded and permanently stabilized. During this period, the slopes are very vulnerable to erosion, and temporary slope drains together with temporary diversions can provide valuable protection. The temporary conduit safely conveys runoff down the disturbed face of an embankment without causing erosion. The practice is maintained until the slope has been sufficiently stabilized to enable it to convey runoff by sheet flow, or until another practice has been installed to convey concentrated runoff from the top of slope to a safe outlet. The outlet from the slope drain should be stabilized.

Sediment Control Practices

Sediment controls interrupt the sediment conveyance process. Once erosion occurs, soil particles are conveyed by runoff away from the source of sediment, and deposited in downslope land areas or in downstream receiving waters. To capture sediment generated during construction, practices are implemented to intercept sediment before it leaves the site; some examples of sediment controls include:

Silt Fence

Silt fence is a temporary sediment barrier consisting of filter fabric attached to supporting posts and entrenched into the soil. This barrier is installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Silt fences have a useful life of one season. They function primarily to slow and pond the water and allow soil particles to settle. Silt fences are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas where overland sheet flows are expected.

Silt fence is a sediment control practice, not an erosion control practice. It is intended to be used in conjunction with other practices that do prevent or control erosion. Improperly applied or installed silt fence will increase erosion.

Silt fences should not be used across streams, channels, ditches or other drainage ways. Silt fences are not capable of effectively filtering the high rates and volumes of water associated with channelized flow.

Straw or Hay Bale Barrier

Straw and hay bale barriers are a type of temporary sediment barrier installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Straw or hay bale barriers have a useful life of less than six months. They function primarily to slow and pond the water and allow soil particles to settle. They are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas that only contribute sheet flow to the device.

Straw or hay bale barriers constitute a sediment control practice, not an erosion control practice. The must be used in conjunction with other practices that do prevent or control erosion. Improperly applied or installed sediment barriers will increase erosion.

Straw or hay bale barriers should not generally be used across streams, channels, ditches or other drainage ways or areas with concentrated flows. Such barriers are not capable of effectively filtering the high rates and volumes of water associated with channelized flow. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than an acre, and provide for frequent monitoring of the barrier. Straw or hay bale barriers installed across a concentrated flow path are subject to undercutting, end cutting, and overtopping. Please note that hay bales can contain a variety of seeds some of which may be invasive plants such as reed canary grass and purple loosestrife. It is suggested that hay bales not be used near important resources such as wetland streams and lakes to prevent the spread of invasive plants .

Erosion Control Mix Berms

An erosion control mix berm is a trapezoidal berm that intercepts sheet flow and ponds runoff, allowing sediment to settle, and filtering sediment as well. They are an environmentally-sensitive and cost-effective alternative to silt fence. An alternative to a simple erosion control mix berm is a "continuous contained berm", consisting of erosion control mix compost encapsulated in a mesh fabric (or "filter sock"). This barrier is installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Erosion control mix berms and socks sometimes offer a better solution than silt fence and other sediment control methods, because the organic material does not require any special trenching, construction, or removal, unlike straw bales, silt fence or coir rolls. This makes the technique very cost-effective.

The erosion control mix is organic, biodegradable, renewable, and can be left onsite. This is particularly important below embankments near streams, as re-entry to remove or maintain a synthetic barrier can cause additional disturbance. Silt fence has to be disposed of as a solid waste, and is often left abandoned on jobsites. Erosion control mix berms can be easily and quickly fixed, if they are disturbed in the course of construction activity.

Temporary Check Dams

Temporary check dams are small temporary dams constructed across a swale or drainage ditch. Check dams are used to reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. Check dams may also trap small amounts of sediment generated in the ditch itself. However, the check dam is not a sediment trapping practice and should not be used as such. The practice is limited to use in small open channels that drain one acre or less. It should not be used in either perennially flowing streams or intermittent stream channels.

Check dams can be constructed of stone. In locations where stone is not available, timber check dams may be considered. Typical applications include:

- Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining, but still need some protection to reduce erosion.
- Permanent ditches or swales which for some reason cannot receive a permanent non-erodible lining for an extended period of time.

- Either temporary or permanent ditches or swales, which need protection during the establishment of grass linings.

Hay or straw bales should not generally be used as check dams, or in any location where there is concentrated flow.

Temporary Storm Drain Inlet Protection

A storm drain inlet protection is a sediment barrier installed around a storm drain drop inlet or curb inlet to reduce sediment discharge. The sediment barrier may be constructed of straw or hay bales, gravel and wire mesh, or concrete blocks and gravel. Sediment removal is accomplished by shallow ponding adjacent to the barrier and resulting settling of the sediment particles.

The purpose of storm drain inlet protection is to prevent sediment from entering a storm drainage system prior to permanent stabilization of the contributing disturbed area. Storm drains made operational before their drainage areas are stabilized can convey large amounts of sediment to storm sewer systems or natural drainage ways. In some cases, the storm drain itself may accumulate sufficient sediment to significantly reduce or eliminate its conveyance capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Temporary Construction Exit

A stabilized construction exit consists of a pad of stone aggregate placed on a geotextile filter fabric, located at any point where traffic will be leaving a construction site to an existing access road way or other paved surface. Its purpose is to reduce or eliminate the tracking of sediment onto public roads by construction vehicles. This helps protect receiving waters from sediment carried by stormwater runoff from public roads.

Temporary Sediment Trap

A sediment trap is a small, temporary ponding area to intercept sediment-laden runoff from small disturbed areas. Intercepted runoff is retained long enough to allow for settling of the coarser sediment particles. A sediment trap is usually installed in a drainage swale or channel, at a storm drain or culvert inlet, or other points of discharge from a disturbed area.

Temporary Sediment Basin

A sediment basin is a water impoundment constructed to capture and store sediment and/or debris. Sediment is removed by temporarily storing sediment-laden runoff, allowing time for the sediment particles to settle. In some instances, settling may be enhanced by the introduction of flocculants. Sediment basins may be made by constructing a dam or embankment or by excavating a depression.

Sediment basins differ from sediment traps, in that basins are engineered impoundment structures, and may serve larger areas than sediment traps.

The sediment basin is designed to:

- Detain stormwater volume and slowly release it to the downstream waterways;
- Trap sediment originating from construction site and prevent subsequent deposition in downstream drainage waterways;
- Provide storage of the trapped sediment and debris.

Construction Dewatering

Construction dewatering must be conducted in a way to prevent sedimentation associated with the management of water removed during construction from excavations, cofferdams, and other work areas that trap stormwater and groundwater. Construction dewatering discharges to surface waters must obtain coverage under either the NPDES Construction General Permit (CGP) (the State Permit Conditions Section details requirements for construction dewatering) or for sites disturbing less than one acre, the NPDES Construction Dewatering General Permit . These permits contain, among other requirements, numeric limits for total suspended solids (TSS).

Construction sites in New Hampshire typically require construction dewatering operations. Excavations that do not "daylight" to existing grade trap either rainwater or groundwater, and cofferdams collect rain, ground or seepage water within the work area. This water needs to be removed before certain operations can be performed or to keep work conditions safe. Contractors typically use ditch pumps to dewater these enclosed areas. If care is not taken to select the point of discharge and provide adequate treatment, the pumped water may discharge to down-gradient natural resources such as lakes, wetlands, or streams, with subsequent sedimentation of those waterbodies.

Construction dewatering activities must be conducted to prevent the discharged water from eroding soil on the site, remove sediment from the collected water, and preserve downgradient natural resources and property.

Flocculants

Flocculants (or coagulants) are natural materials or chemicals that cause colloidal particles (clay) to coagulate. The coagulated particles group together to form flocs, which settle out of detained stormwater.

Flocculants can be used in conjunction with sediment basins and sediment traps to remove suspended clay and fine silt particles from stormwater runoff prior to discharge. Use of flocculants improves the ability of these settling facilities to remove finer particles than would be removed otherwise and can increase the percentage of fines removed during the detention period.

Flocculants should only be used upon prior approval by NH DES.

Winter Weather Stabilization and Construction Practices

A project involving construction activity extending beyond one construction season will require measures to stabilize the site for the over-winter period. If a construction site is not stabilized with pavement, a road gravel base, 85 % mature vegetation cover, or riprap by October 15, then the site must be protected with over-winter stabilization. The winter construction period is from October 15 through May 15.

Winter excavation and earthwork activities need to be limited in extent and duration, to minimize potential erosion and sedimentation impacts. Various erosion and sediment control practices need to be applied, as discussed in Volume 3 of the New Hampshire Stormwater Manual, to stabilize a project site during the winter period.

7-4. Selection Criteria for Best Management Practices

There is no single stormwater best management practice that is appropriate for every development site. Soils, topography, slope, and many other factors make each site unique and require individual assessments to determine the most suitable stormwater BMPs. Depending on the needs of a site, BMPs can be implemented to meet one or more of the following management objectives:

- Recharge groundwater and reduce total runoff volumes
- Protect stream channels
- Control peak rates for flood control
- Reduce pollutant loads

Often, a site has a combination of management objectives and requires BMPs that achieve multiple objectives. The selection of BMPs requires careful consideration of these objectives, as well as a variety of constraints that may influence the effective application of particular types of BMPS. In some situations, two or more BMPs in a series may be necessary to achieve sufficient treatment to reduce pollutant loads.

This section provides an overview of the screening criteria that should be considered when selecting BMPs. These criteria are intended to provide only general guidance in the selection of BMPs and should not be used in the place of best professional judgment. Volume 2 of the New Hampshire Stormwater Manual provides a detailed discussion of the criteria in order to select measures that are appropriate for meeting management objectives while taking into consideration unique site constraints.

Land Use Criteria

Selecting a stormwater BMP requires consideration of, among other factors, space availability, fitting with the neighborhood character, housing density, and future growth and development. Some practices require very little space and some are land intensive. Some practices blend in with the landscape and others are less compatible. As discussed in Volume 2 of the New Hampshire Stormwater Manual, selection of BMPs may be dependent on which of the following land-use settings apply:

- Rural
- Residential
- Roads and Highways
- Commercial Development
- High Load Areas

Of particular note are high-load areas, which include areas where activities involve storage of regulated substances that may be exposed to rainfall or runoff. These areas typically generate higher concentrations of hydrocarbons, metals, or suspended solids than found in typical stormwater runoff and may include industrial facilities, petroleum storage or dispensing facilities, vehicle fueling or maintenance stations, fleet storage areas, public works storage areas, road salt facilities, commercial nurseries, non-residential facilities with uncoated metal roofs, or facilities with outdoor storage, loading, or unloading of hazardous substances. These areas have particular requirements for the management of stormwater, including the prohibition of infiltration of stormwater runoff, in order to protect groundwater supplies.

Site Physical Feasibility Factors

Physical site constraints such as the infiltration capacity of the soil, depth to bedrock or water table, size of the drainage area, and slope can limit the selection of stormwater BMPs. Depending on the physical site constraints, certain BMPs may be too costly to install or may be ineffective. NHDES has established requirements for physical feasibility factors. These requirements are described in the Alteration of Terrain Program Administrative Rules (Env-Wq 1500) and are summarized in Volume 2 of the New Hampshire Stormwater Manual. Physical feasibility criteria include:

- Soil infiltration capacity
- Water table
- Drainage area
- Slopes

Watershed Resource Factors

Chapter 3 discussed how the impacts of development activities can be far reaching. Because of this, it is important to look not only at the impacts the development will have at a site, but also how downstream resources may be impacted by development activities. The following downstream resources should be considered when selecting stormwater BMPs:

- Sensitive receiving waters such as impaired waters, outstanding resources waters, and prime wetlands , located downstream of a development site;
- Water supplies: aquifers and surface waters
- Lakes and ponds
- Estuary and Coastal Areas

BMP Capability Factors

Pollutant removal efficiencies are dependent on many variables including proper selection and installation of the BMP, proper placement of the BMP on a site, and proper maintenance. Various field and laboratory tests have determined average expected pollutant removal efficiencies for various management practices. These values, expressed as a percentage of the total load, can be seen in Chapter 8. As more studies are conducted and the amount of pollutant removal efficiency data grows, these estimates may change to more accurately reflect the level of stormwater treatment provided through these practices.

Maintenance Factors

Regular inspection and maintenance is essential for long-term effectiveness of stormwater BMPs. Sediment, trash, and other debris can accumulate in BMPs and needs to be removed periodically. Pre-treatment devices, such as sediment forebays, can reduce the amount of sediment accumulation in the primary treatment device; however, pre-treatment practices also require maintenance. If not properly maintained, the BMP will not operate as designed and will not provide effective treatment of stormwater runoff. This jeopardizes water quality and may violate permit conditions. All stormwater BMPs require maintenance; however, the frequency and difficulty of maintenance activities and the equipment needed to carry them out varies. Maintenance criteria need to be considered when selecting a stormwater BMP.

Community and Environmental Factors

It is important to think about how a stormwater BMP will fit into the community. Some BMPs may be aesthetically attractive and will blend into the local landscape and may actually become a landscape feature. Others may pose a safety risk, such as deep standing water, that may be unsuitable for a residential area with small children or increase mosquito habitat and the potential for human exposure to mosquito-borne illnesses. Some BMPs are more expensive to construct and maintain than others. It is important that the municipality, home association, or homeowner will be able to afford and maintain the practice. In addition, some practices may have other environmental benefits; for example, some BMPS can provide wildlife and wetland habitat.

7-5. Stormwater System Operation and Maintenance Plan

It is essential for all stormwater management systems to be carefully planned and to undergo routine inspection and maintenance in order to operate at the designed efficiency. To more easily track the operation and maintenance activities, including the activity schedule, the person(s) responsible, and the maintenance activity records, it is recommended (and sometimes required) that a stormwater management plan is developed and implemented. If a plan is being developed under a specific permit, check with the permit program to see if additional plan elements are required. At a minimum, the Stormwater System Operation and Maintenance Plan should include the following elements:

- The names of the responsible parties who will implement the Plan,
- The frequency of inspections,
- And inspection checklist to be used during each inspection,
- And inspection and maintenance log to document each activity,
- A plan showing the locations of all the stormwater practices described in the plan.

7-6. Road Salt and Deicing Minimization Plan

New Hampshire's cold winter climate and snowfall require plowing and de-icing of roadways and other impervious surfaces to allow for safer travel. The most commonly used de-icing salt is sodium chloride (NaCl). In general, road salt is used to reduce the adherence of snow to the pavement, keep the snow in a "mealy" condition to allow for easier plowing, and to prevent the formation of ice or snow ice (hard pack).

Although road salt makes for safer travel, it is hard on the environment and can pose a risk to drinking water supplies. Roadside vegetation is visibly impacted from road salt including burned grass and shrubs. High chloride concentrations can be toxic to some aquatic life, including certain types of macroinvertebrates and freshwater fish. New Hampshire has several surface waters that are listed as impaired in the Section 305(b) and 303(d) Surface Water Quality Report. The majority of these waterbodies are in heavily urbanized areas. Chloride impairments in surface waters along the Interstate 93 corridor in southern New Hampshire have lead to the development of several chloride TMDLs for these waters. In addition to the habitat and water quality impacts, private wells can become contaminated by chloride.

Unfortunately, the systems and treatment practices commonly used to treat stormwater runoff do not remove chloride. Practices that do remove chloride, such as reverse osmosis, are very costly. Because of this, source control (i.e., using less salt in the first place), is the best way to prevent further chloride contamination.

To address the concerns associated with the application of chlorides and other deicing materials, NHDES requests the development of a Road Salt and Deicing Minimization Plan when a development will create one acre or more of pavement, including parking lots and roadways. The plan should address the policies that the development will keep in place to minimize salt and other deicer use after the project has been completed. A component of the plan should include tracking the use of salt and other deicers for each storm event and compiling salt use data annually.

New Hampshire does not yet have salt reduction guidance, but recommends following the guidelines available in the *Minnesota Winter Parking Lot and Sidewalk Maintenance Manual* (www.pca.state.mn.us/publications/parkinglotmanual.pdf) and the *Minnesota Snow and Ice Control* handbook, (www.mnltap.umn.edu/pdf/snowicecontrolhandbook.pdf). Deicing application rate guidelines and a form for tracking salt and other deicer usage are included in Appendix C.

Chapter 7 References

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